Pneumatic tire substitutes. S. Murray Jones. NDRC, Section C-2. [October, 1942.]

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Report prepared
by
S. Murray Jones, Technical Aide, Section C-2
OFFICE OF SCIENTIFIC RESEARCH AND DEVELOPMENT
122 East 42nd Street, New York, New York

SUMMARY OF [illegible]

1. On March 30, 1942 the Office of Scientific Research and Development was requested by the Quartermaster Corps to "Procure and investigate the present development and patents covering devices that will eliminate the use of rubber tires and make recommendations as to the possibilities of further development."

2. Of the several thousand devices studied with the cooperation of the military, industry, and private individuals, the Martin rubber-spoke wheel has shown the most promise in road and proving ground tests.

   a. The saving in rubber amounts to about 15% to 40% for "rugged" and more for "non-destructive" use. There is also possible saving of studs [illegible] use of wood.

   b. It is [illegible] road.

   c. It is operable with several [illegible].

   d. Dynamically the wheel appears to be [illegible] as a pneumatic tire at the higher speeds; however, a "bump" [illegible] at the lower speeds appears to [illegible] than a pneumatic tire. This does not [illegible] true of the "non-destructive" design.

   e. However, tests are not complete and the life of the wheel remains to be determined.

3. Nothing has so far been discovered or tested which encourages the hope that equal service can be had from a wheel from which all rubber has been eliminated.

4. However, since other wheels, some of which carry no rubber, are [illegible] brought to test.

ection I

SUMMARY

Statement of problem

On March 20, 1942 the Quartermaster Motor Transport Division directed us to "thoroughly investigate the present development to provide covering devices that will eliminate the use of rubber tires and make recommendations as to the possibilities of further development."

Although the directive requests us to investigate and make recommendations for devices which will completely eliminate the use of rubber, this has been broadened to include devices which might contain some rubber but which would contain materially less than the present pneumatic tire and tube.

Since issuing this directive the Quartermaster Motor Transport Division has been completely transferred to Ordnance, and as a result of conferences with the Ordnance officers in Detroit during the week of September 28th we were advised that this project, which was originally intended to cover only motor transport vehicles, should now be broadened to include also other Ordnance vehicles as gun carriages, armored cars, scout cars, and other combat vehicles which are presently equipped with pneumatic tires.

The pneumatic tire unquestionably does a remarkable job of handling very complicated forces which result principally from starting, stopping, and cornering an automotive vehicle. During the many years of study and development of the pneumatic tire, particularly prior to their general use on trucks and buses, numerous substitute tires and wheels were perfected and tried. Some, however, had been found which received public acceptance. These facts, plus the information obtained from a preliminary survey among the automotive and rubber people, made it seem apparent that no satisfactory substitute could be found which would have comparable performance and life to that of the pneumatic without using an equal amount of rubber or even more than the pneumatic tire.

Past efforts to make a substitute for the pneumatic have used steel springs in one form or another to obtain their resiliency. In addition to the undesirable amount of unsprung weight in most of these designs, the total weight of steel required and the amount of machine work involved would prevent their use today because of the critical shortage of steels and machine tool equipment.

Many of these substitute designs have proposed a solid rubber tread for traction or wear. The area of tread in contact with the road in most of these designs is materially less than that of the pneumatic. Tread wear is roughly in inverse proportion to the area in contact with the road. Thus, in some instances more rubber would be used with this construction than in the pneumatic, for the same mileage. Even the possible advantage of being puncture-proof would hardly offset this disadvantage.

Procedure

The Patent Office was requested to furnish us with all of the existing patents which relate to wheels or tires which have been designed as a substitute for the present pneumatic tire. These patents, several thousand of them, were assembled and reviewed with the assistance of the officers of the Motor Transport Division, the National Inventors' Council and the chief engineers of the Budd Wheel Company, Kelsey Hayes Wheel Company, and Motor Wheel Corporation. While no specific designs were picked from these patents the survey did indicate in a general way types which might be considered feasible and those which could not be used for one reason or another.

Initial conferences were held with the automotive and rubber manufacturers to determine what experimental work had been done in the past in connection with pneumatic tire substitutes and to determine whether these people had any work in progress or any ideas which would be worth following up. They had apparently done very little work along this line which they were willing to talk about. The automotive and rubber people had formed a committee from the Society of Automotive Engineers entitled, "The Automobile and Rubber Industry's Tire Committee of the S. A. E. War Engineering Board"; but the principal advice which we received from them, both verbal and written, was that the present automotive vehicles had been designed for pneumatic tires and that no other type could be satisfactorily used on them, and furthermore that we should not be wasting our time and money hunting for such substitutes; that the time, money and materials required for developing and testing substitute wheel or tire structures should be put into speeding up the new synthetic rubber plants.

After the first preliminary survey it was decided that the wheel manufacturing companies, principally Budd, Kelsey Hayes, and Motor Wheel, would be most helpful in attacking this problem; and the chief engineers of each of these companies evidenced an interest in our problem and voiced a willingness to make a study and procure experimental wheels for test.

The Motor Transport Division informed us that approximately 30% of the total rubber requirement for Army automotive vehicles was used on the 2½ ton truck which takes the 7.50 x 20 tire. Thus, to accom-

lish any real saving in rubber a substitute would have to be designed for this vehicle. However, in order to reduce both the time and expense factor in endeavoring to obtain a pneumatic tire substitute it was agreed with the Ordnance (formerly Quartermaster) Motor Transport Division that the first experimental wheels should be made for the ¼ ton vehicle, the "jeep", which takes the 6.00 x 16 tire, and then proceed to the design of the larger tire when something was found which appeared satisfactory for the ¼ ton vehicle.

The problem was further divided into the following classifications in the belief that it would be difficult to find a substitute for the pneumatic tire which would be universally used by the Army for both combat and administrative use as the present pneumatic. These classifications were:

1. A tire or wheel which might be used as a spare or a delivery tire.

2. A tire or wheel which might be used with some speed limitation or which also used for administrative purposes only, or for slow moving, low mileage combat vehicles or equipment.

3. A tire or wheel which might be acceptable for combat use.

A great material for any of these substitute tires or wheels, which uses little or no rubber, and which has some degree of resiliency is most difficult to find. In order not to delay the test of some of the wheel and tire structures now being built it is likely that some of them will have to be equipped with a rubber tread. The rubber companies, the carpet manufacturers, several independent chemists and such other people as Johns Manville, the Firestone Company, and the Standard Oil Development Company have all been consulted and are actively working on this problem.

Inquiries are now being made through the United States Forest Products Laboratory in Madison, Wisconsin, and some of the manufacturers of compressed woods to determine whether compressed wood might be substituted for the steel now used for the wheel center and rim.

Summary of Work Completed and in Preparation

The Budd Wheel Company were the first to build an experimental resilient wheel structure under this program. Their wheel consisted of coiled springs between an inner and an outer rim. Two such wheels were made up, one having a continuous rim and the other a demountable rim. Preliminary tests of these two types were made in Detroit and as a result it was decided, principally because of the large weight differential between the two types, to continue work only on the continuous rim. This continuous rim type wheel was shipped to Camp Holabird and given a preliminary test on July 6, 1942. These preliminary tests

indicated that fatigue and cracking of the outer rim was taking place because there was no resilient tread. As a result of these preliminary tests the wheel was re-designed and an effort made to materially decrease its weight. The second wheels were sent to test at Holabird on August 12, 1942. However, fatigue developed in one of the coiled spring structures quite rapidly, and a post-mortem analysis indicated that the spring design was too skimpy. These wheels are now being re-designed and re-built and it is anticipated that by the next tests some form of resilient tread structure will be available and will be used on these wheels. This should eliminate or materially reduce the rim fatigue.

Preliminary tests were conducted at Camp Holabird on August 25th of five different types of steel or wire constructions. Three of these could be classed as front or delivery tires; the other two appear to have possibilities for use for administrative as well as combat service.

Little interest was evidenced by the Army in the other three tires or delivery tires.

As a result of the tests at Holabird the Ordnance Department requested us to obtain ten wheels each of the two resilient structures, these being the Martin and Hajos wheels. Contracts totaling $ 5,000.00 were placed for the construction of these wheels.

Photographs and drawings, along with other pertinent data on the wheels which were tested at Camp Holabird, will be found in Section I of this report. The signal corps motion picture of the tests at Holabird and a film of these is available. Further tests were made on the Martin wheel at the Ford plant and test course in Detroit. A moving picture film was taken of these tests and also is available.

Five other experimental wheels are now being built under contracts totalling $2,220., and wheel manufacturing companies and individuals who are using their own funds will supply additional three experimental wheels for tests.

Present plans indicate that all of these wheels will be built and ready for preliminary tests by the latter part of November or early December. Drawings and a brief description of these wheels will be found in Section II of this report.

It is expected that by the time these experimental wheels are ready for test at least three or four possible tread materials will be ready for use on these wheels. These tread materials include two or three different types of impregnated carpet-like material, and one or two others might be classed as synthetic rubber substitutes which

probably could not be used satisfactorily in the construction of a pneumatic tire except for the tread material.

The only tests which have been completed of any possible tread materials are tests which have been made by the United States Rubber Company on their tire sandal, which in addition to its possible use as a sandal or cover for the pneumatic tire is capable of being used as a tread material on one of our resilient wheel structures. The other material which has had quite comprehensive tests is a rubber-like material developed by G. E. Heinemeier and has been given quite comprehensive tests by the Ford Motor Company, including tests as a tread on a passenger tire. Those tests have indicated that as a tread this material has approximately only the wearing quality of Nickel.

In view of the fears of the automotive industry and the rubber companies that the use of synthetic type pneumatic tire would promptly result in fatigue and crystallization of bearing and axle structures, it was determined that tests should be made on a standard passenger car with some form of non-resilient wheel constructions to determine when and how fatigue takes place. These tests, using wooden tires, are being made in conjunction with the automotive section of the War Production Board, and are being conducted by the International Harvester Company on a light truck and by either the Studebaker or Ford Motor Company on a passenger car and should be completed by the end of November.

On a Substitute for the Pneumatic Tire Be Found

If such a substitute is to contain no rubber, natural or synthetic, and must be capable of use for combat service with no speed limitation, the answer at this point in our investigation is "No".

It does appear, however, that a satisfactory all-purpose wheel for combat and administrative use may be developed under this project which uses materially less rubber than the standard military pneumatic tire.

At this stage of the work, the Kelsey wheel seems to have the most promise. Being gunfire-proof, and capable of being driven with almost half the spokes out and part of the rim broken, this wheel, if its life under road test proves satisfactory, appears to be even superior to the pneumatic tire.

As a possible substitute for the spare tire, the Grossé "Minute Wheel" seems to be the simplest and most satisfactory. This wheel uses materially less steel than the standard wheel center and rim for the present pneumatic spare tire. It is installed in much less time than it takes to change a pneumatic tire.

Section II

TIRES OR WHEELS WHICH HAVE BEEN BUILT AND GIVEN PRELIMINARY TESTS

Summary

This Section contains photographs, drawings, and information on the materials used, weights, and other pertinent data relating to the six wheels which have been designed and built and given preliminary tests at the Ordnance Motor Transport Base at Camp Holabird. All of these tests were conducted under the supervision of Captain A. E. Cleveland, Liaison Officer under this Project, and Captain R. H. Clark, Chief Test Officer.

The first three wheels tested have no resiliency other than the small amount contained in the materials themselves, and for purposes of classification have been considered as possible substitutes for the pneumatic spare tire, or for use as a delivery tire. (A delivery tire is one which would be installed on the car by the manufacturer when delivered, and left on the car until placed in actual service.) These three are identified for the purposes of this report as follows:

1. Grass-Minute Wheel
2. Atlas-Wooden Tire
3. Goodyear-Impregnated Cotton Tire

The remaining three which have some form of resilient structure and may be classed as wheels for administrative or possible combat use are as follows:

4. Budd-Coiled Spring Tire
5. Ampat Hajos-Spring Spoke Wheel
6. Martin-Rubber Spoke Wheel

As a result of the preliminary tests which were conducted at Camp Holabird the Budd Wheel Company have been requested to redesign their wheel and submit it for further test; and the Ordnance Department have formally requested ten each of the Ampat-Hajos and Martin wheels for more comprehensive tests.

Additional tests were made on the Martin wheel at Detroit, and as a result of further inspection of this wheel by Lieutenant Colonel J. M. Colby and other officers at Detroit it was suggested that the number of the Martin type wheels to be supplied be increased to fifteen or twenty, the majority to be furnished with the mud and snow tread and four or five with the sand tread.

It is expected that the three resilient wheel structures, numbers 4, 5, and 6, above, which are now being built for further test, will be ready within the next six to eight weeks.

GRASSO MINUTE WHEEL

SUBSTITUTE FOR THE PNEUMATIC SPARE TIRE

The Grasso Minute Wheel has been designed as an emergency wheel to replace the pneumatic spare tire. Thus, an automotive vehicle using pneumatic tires can operate without a pneumatic spare tire and wheel. In the case of four wheeled vehicles this would release one complete casing, tube and wheel, and in the case of six wheeled vehicles such as the 2½ ton truck would release two casings, tubes and wheels, thus releasing both rubber and steel.

This wheel is capable of being quickly installed in the event of a flat tire without the use of a jack. In the event of a puncture or blowout, a special hub plate is mounted using the same bolts as those which attach the wheel. After mounting the hub plate, the Grasso wheel is locked on this plate in an off center position with the tire flat. Driving the car one revolution of the wheel results in locking the Grasso wheel in the center position, and the car is then driven to the repair shop.

If all the wheels of the vehicle were equipped with the special mounting plate, or hub extensions were modified and made square instead of round, this wheel could be installed, after a puncture or blowout in approximately one minute. From this standpoint this wheel may have some application for combat vehicles where continuity of operation may be more important than operation at high speed.

One possible objection to this type of wheel, particularly if the car had to be driven any appreciable distance to a repair center, is (the fact) that the stress on the axle and bearing is increased somewhat by carrying the weight of the car further out on the axle and thus increasing the moment arm between the wheel and the bearings. At reduced speeds this should not be two objectionable.

The photographs, Figure 1 and 2, show this wheel before and after installation on the car. The drawing, Figure 3, indicates the construction and action of the wheel.

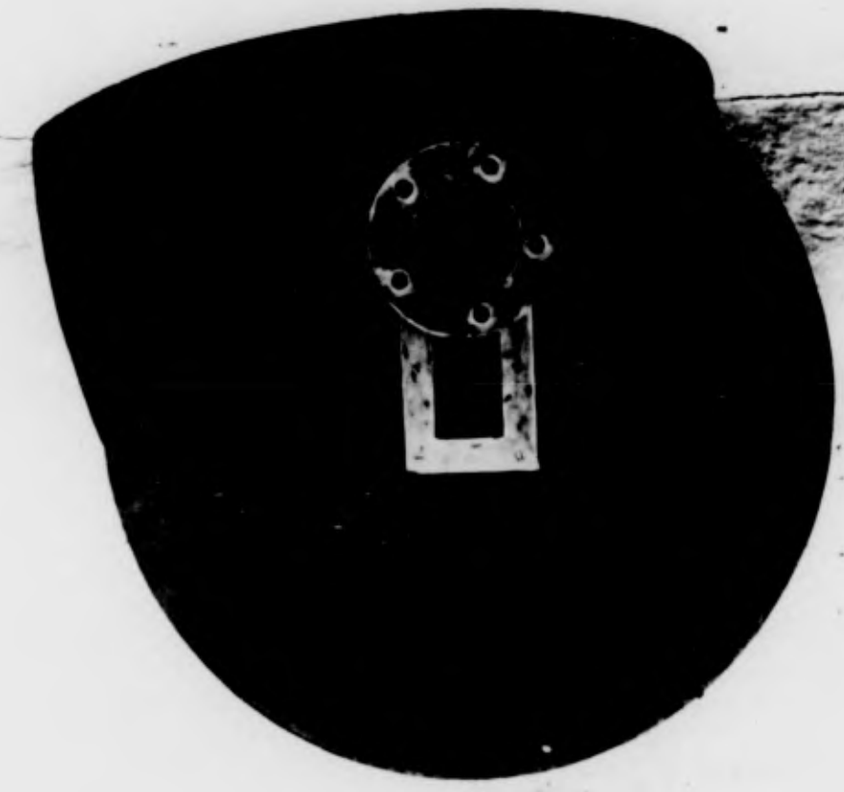
The total weight of this wheel is 31 pounds, plus an additional 4 pounds for the special hub plate. As submitted for test at Holabird, it consisted of only plywood and steel in the following amounts:

Plywood	-	22 lbs.
Steel	-	9 lbs.
Total Wheel	-	31 lbs.
Special Hub Plate	-	4 lbs.

Table I shows a comparison of the weights of rubber, steel, and other materials between the five pneumatic tires and the four tires with the Grasse spare. These weights are based on the 6.40 x 16 tire as used on the ¼ ton 4 x 4 vehicle.

TABLE I

Materials	Weight Five Pneumatic Tires, Standard Tubes and Wheels	Weight Four Pneumatic Tires, Standard Tubes and Wheels and One Grasse Wheel	Saving by Use of Grasse Wheel
Fiber Cord and Fabric	127.5 lbs.	101.0 lbs.	26.5 lbs.
Cotton	25.0 lbs.	20.0 lbs.	5.0 lbs.
Steel	123.5 lbs.	112.2 lbs.	11.3 lbs.
Wood	---	22.0 lbs.	22.0 lbs.
Total	276.0 lbs.	255.2 lbs.	---



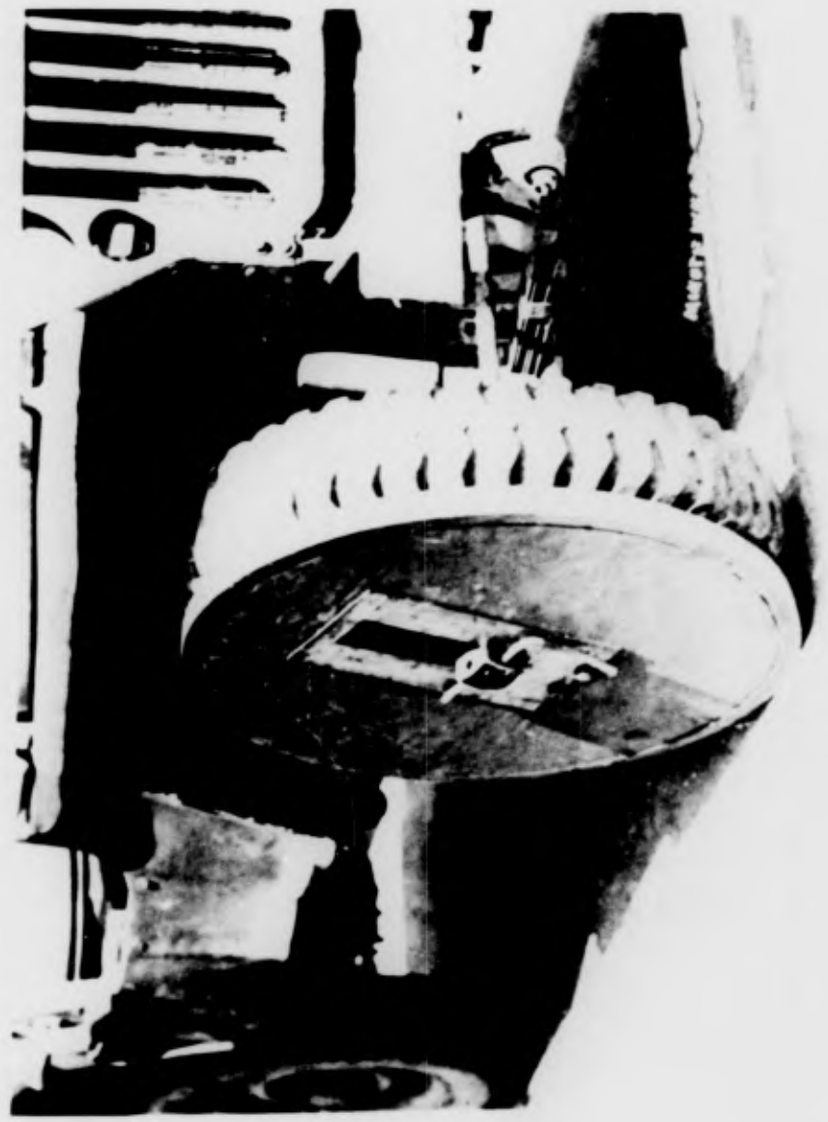


Fig. 2

Fig. 1.

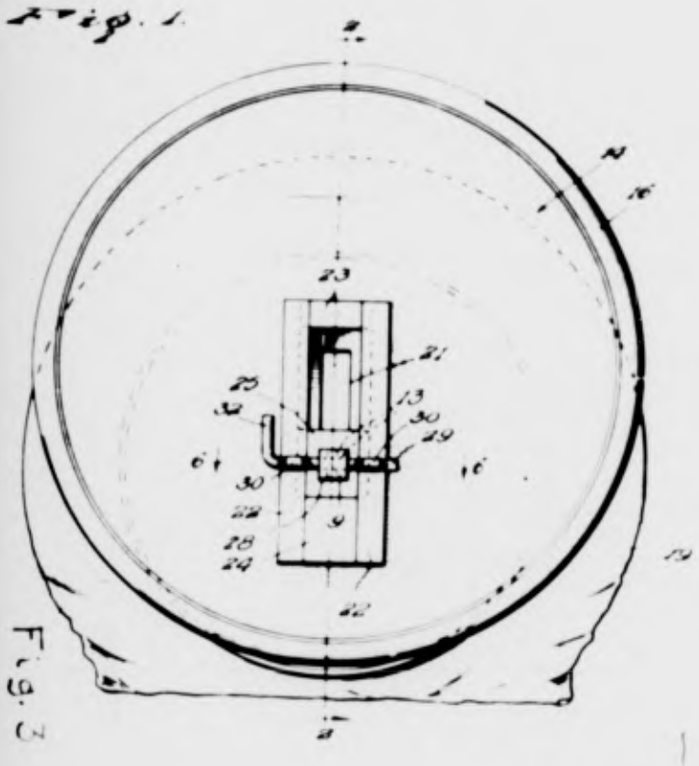
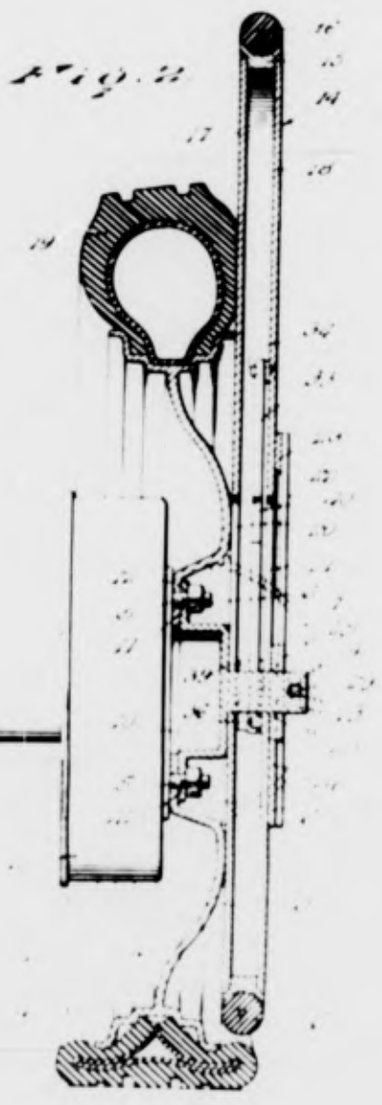


Fig. 2.



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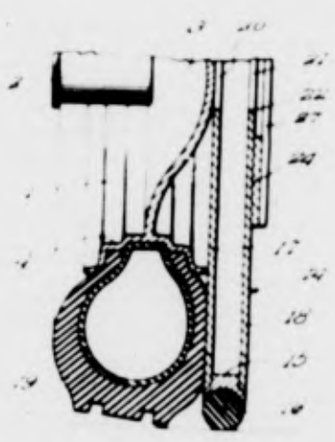


Fig. 4.

Fig. 5.

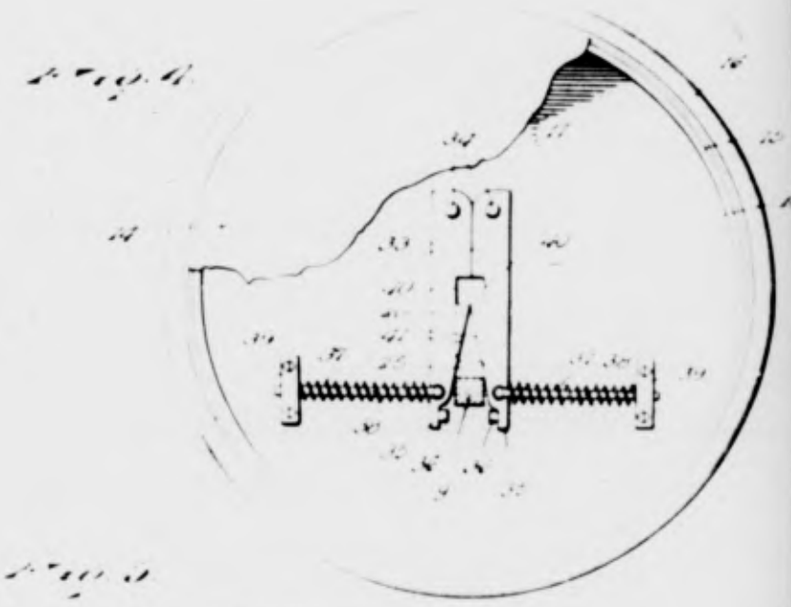


Fig. 6.

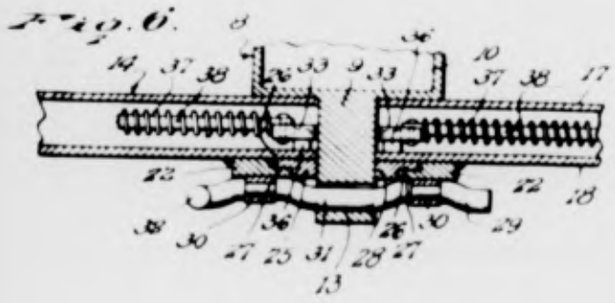
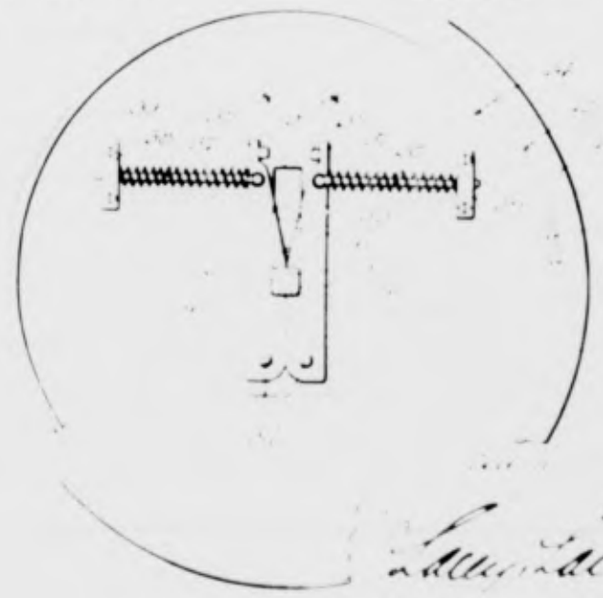


Fig. 7.



ATLAS WOODEN TIRE

SUBSTITUTE FOR THE PNEUMATIC SPARE TIRE

There have been many types of wooden tire and wheel constructions suggested since the shortage of rubber. Many inventors and other people have proposed their use as a complete substitute for the pneumatic tire. It would not be our recommendation, nor would we consider the use of the wooden tire on automotive vehicles for anything more than a spare or delivery tire, except possibly for very slow speed and low mileage vehicles.

The automotive people properly so, fear the use of any non-resilient tire or wheel on the present automotive vehicle from the standpoint of fatigue and crystallization of bearing and axle structures. Tests are now in progress to determine just how quickly this fatigue does take place on a light truck and also a civilian passenger car.

It is reasonable to assume that fatigue will take place rather rapidly on some of the present day vehicles. Since the change over from the high pressure pneumatic tire to our low pressure balloon type tire, bearing and axle structures have all been re-designed and their weights and strength reduced materially for the reason that the balloon tire absorbs many of the small road vibrations which were not absorbed in the older high pressure tires.

The Atlas wooden tire has been designed to mount on the standard wheel center. As constructed for test, it was made from laminated white oak and assembled so that the grain of the wood is perpendicular to the road.

The photographs, Figures 4 and 5, show a side and end view of the tire and indicate its general construction.

The total weight of this tire for the 6.00 x 16 size is 51-3/4 pounds and its estimated satisfactory mileage is somewhere between 250 and 300 miles. The tire is made almost entirely of wood, with the exception of a small amount of metal for assembly and holding bolts, as indicated below:

Wood	-	47-3/4 lbs.
Iron Bolts	-	4 lbs.
Total Tire	-	51-3/4 lbs.
Wheel Center and Rim	-	23-3/4 lbs.
Total Tire and Wheel	-	75-1/2 lbs.

The comperable weight of the standard pneumatic tire and tube is 31.5 lbs., which with the wheel makes a total weight of 55½ lbs.

It is estimated that in small quantity lots these tires could be produced for approximately $20.00 to $25.00 each.

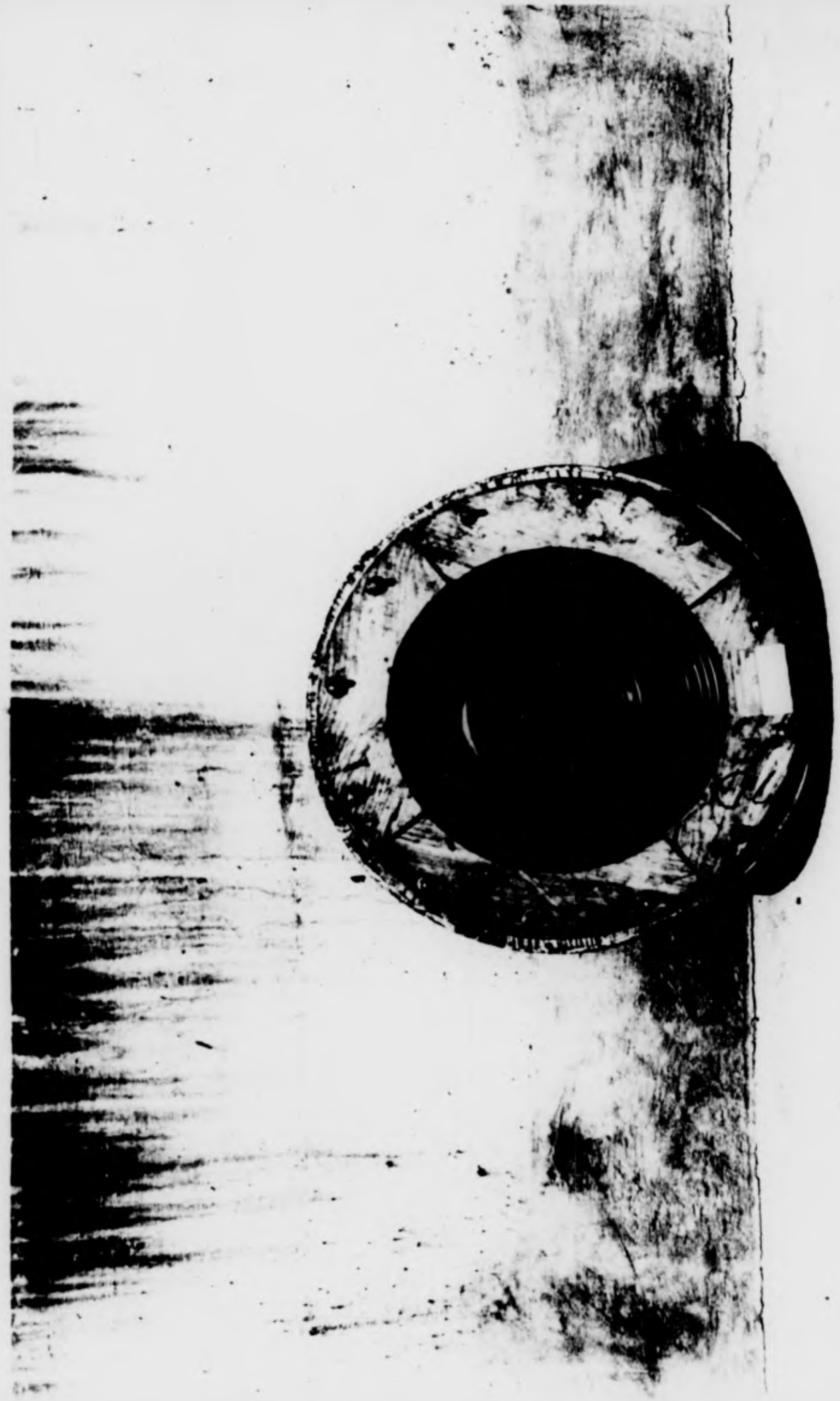


Fig. 4

Fig. 5

GOODYEAR-I[illegible]EGRATED COTTON FABRIC TIRE

SUBSTITUTE FOR PNEUMATIC SPARE TIRE

This tire made by the Goodyear Tire and Rubber Company was developed during the course of their experimentation with many different types of materials which might be used to replace the pneumatic tire, or for cover. for the pneumatic. It is still in the experimental stage and Goodyear do not consider that it has been yet developed to the point of being a marketable product. This particular type could only be used as a complete tire, or, as indicated further in this report, as a tread material for one of the resilient wheel structures which is being designed and tested.

This tire was designed for the standard automobile rim. As tested, it consisted of Thiokol impregnated cotton fabric. Other impregnations might be used. The cotton fabric consists of short lengths of the regular tire cord cut and assembled so that the fibers are substantially on end with respect to the road. As experimentally built, it consists of a series of rings, 2" thick and $\frac{1}{4}$" wide, assembled together for the desired width of tread. The photographs, Figures 6 and 7, show a side and front view of the tire and the drawing, Figure 8, indicates the construction and assembly.

The weights and materials used are indicated following:

Wood Filler	- 29 lbs.
Impregnated Fabric	- 32 lbs.
Steel Flanges and Bolts	- 44 lbs.
Total Tire	- 105 lbs.
Wheel	- 23 3/4 lbs.
Total Tire and Wheel	- 128 3/4 lbs.**

* Consists approximately of 44% by weight of cotton and 44% Thiokol.

** This wheel, like most others submitted for test, was a homemade experimental wheel. If put into production, the weight of wood and steel could be materially reduced so that the total weight of the tire and wheel would not exceed 100 pounds.

GOODYEAR-THIOKOL IMPREGNATED COTTON FABRIC TIRE

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This tire was designed for the standard automobile tire. As tested, it consisted of Thiokol impregnated cotton fabric. Other impregnations might be used. The cotton fabric consists of short lengths of the regular tire cord cut and assembled so that the fibers are substantially on end with respect to the load. As experimentally built, it consists of a series of rings, 2" thick and 4" wide, assembled together for the desired width of tread. The photographs, Figures 6 and 7, show a side and front view of the tire and the drawing, Figure 8, indicates the construction and assembly.

The weights and materials used are tabulated following:

Wood Filler	22 lbs.
Impregnated fabric	52 lbs.
Steel Flanges and Bolts	41 lbs.
Total Tire	105 lbs.
Wheel	23 3/4 lbs.
Total Tire and Wheel	128 3/4 lbs.**

* Consists approximately of 59% by weight of cotton and 41% Thiokol.

** This wheel, like most others submitted for test, was a homemade experimental wheel. If put into production, the weight of wood and steel could be materially reduced so that the total weight of the tire and wheel would not exceed 100 pounds.

As tested one run by the Goodyear people over typical concrete, black top and dirt or gravel roads of northern China, this tire ran some 1500 miles at average speeds of from 30 to 35 miles per hour, with approximately 5/8" wear of the tread. No bunching or other effects occurred which would damage the tire as a running wheel.

The tire has reasonable cushioning but of course not comparable to the pneumatic. It has adequate traction which is comparable to the pneumatic. Thus, in its present form it should be considered only as a possible spare or delivery tire.

It is estimated that on a small scale production basis these tires would be produced for approximately $60.00 each. As a spare tire it is likely that the depth of the ribs could be cut in half, thus reducing the weight and cost substantially.

In its present form this tire uses approximately 14 to 15 pounds of Thiokol compound. The same size pneumatic tire and tube would use approximately 18 to 20 pounds of Thiokol compound. On a comparable mileage test a thick type of construction would therefore apparently not result in any appreciable saving of Thiokol or other synthetic rubbers which might be used, as compared to the pneumatic.

If by using some other inexpensive impermeable compound, which could not be used in the pneumatic tire, approximately the same mileage could be obtained it would seem to have a possible further application.

Fig. 6

TIRE SUBSTITUTE

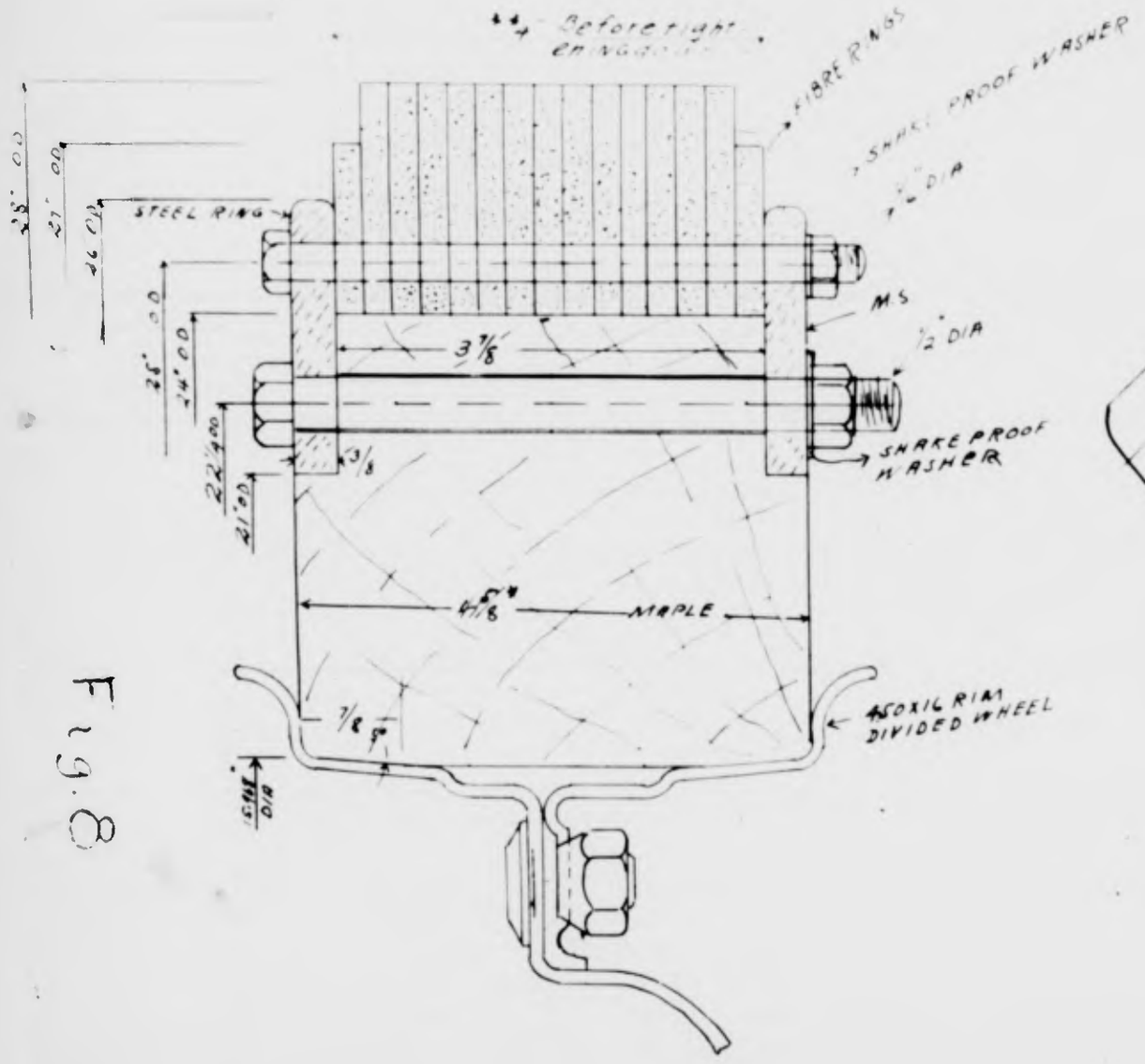
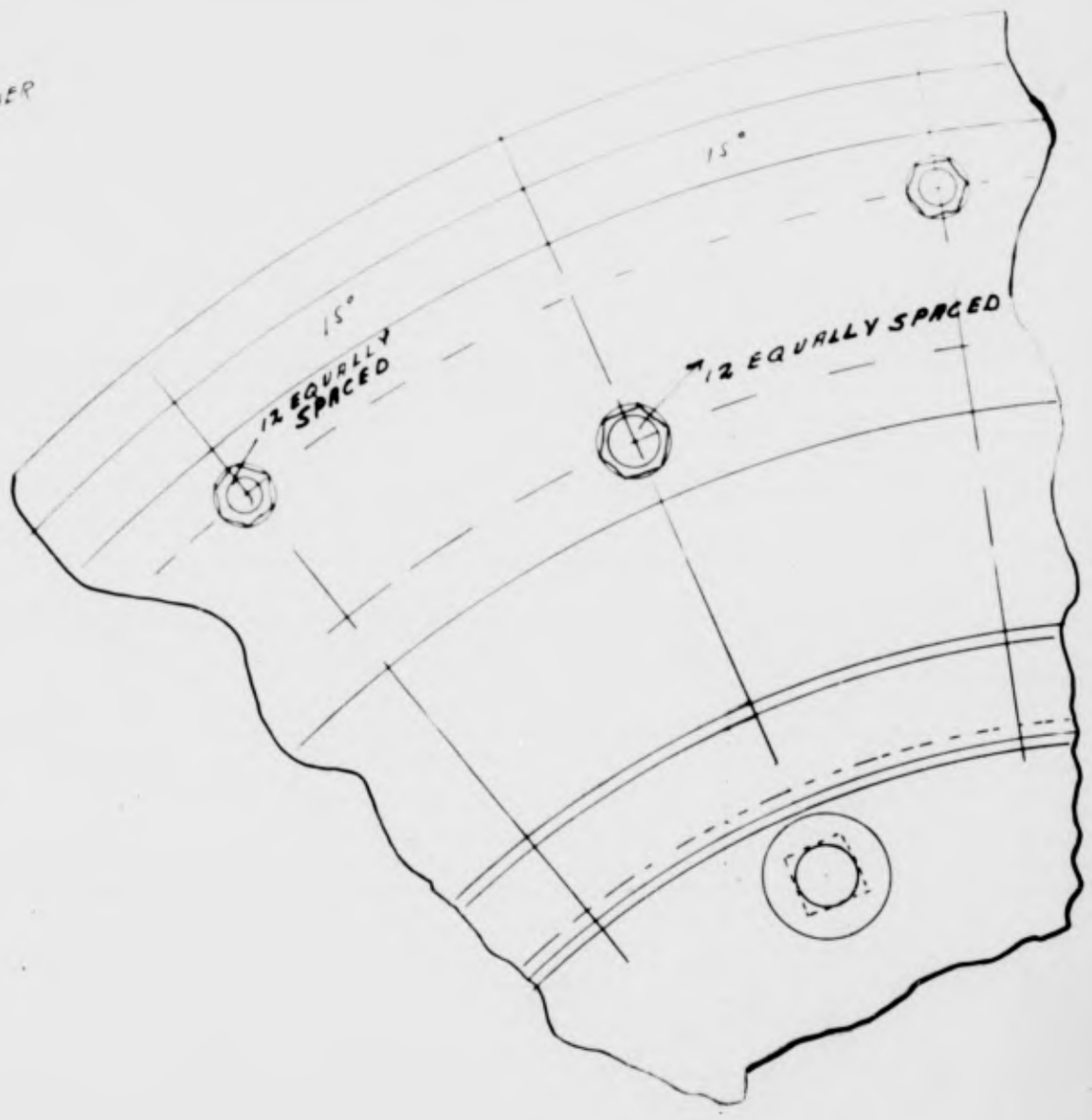


FIG 8



* THE MAPLE RING IS MADE 1/8" WIDER THAN RIM WIDTH TO AFFECT A SQUEEZE FIT ON RIM.

** THE RINGS ARE WIDER THAN THE WHEEL TO AFFECT A TIGHT COMPRESSION

The first two wheels were submitted for test at Camp Holabird on July 6th. These wheels had been given some preliminary tests at Detroit before being shipped to Holabird. From these preliminary tests it was evident that early failure of the outer rim would occur. This was at least partly due to the fact that the tread which had been used for these early tests consisted of wooden blocks with a narrow outer steel rim. Thus, the hunt began for a suitable resilient tread material which would not use rubber.

These preliminary tests did indicate however, and to the surprise of the majority of those present at the tests, that the lateral strength of the wide base coiled spring which had been used was ample for turning corners at relatively high speed.

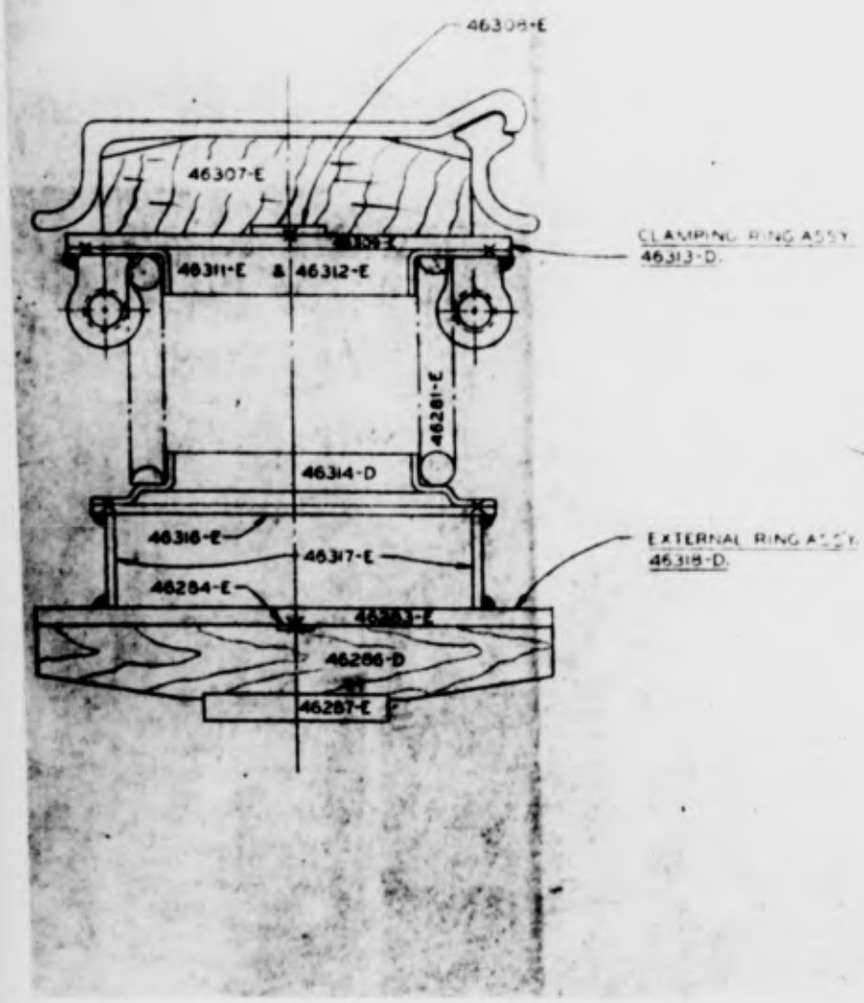
These first tests indicated certain desirable changes in design. A second set of wheels still using the same wood and steel tread was made and shipped to Holabird for a second preliminary test. In the re-design, an effort had been made to cut the weight to an absolute minimum, and as a result one of the coiled springs showed early fatigue and crystallization, either because of an attempt to cut the weight too much or possibly defective steel.

The weight and materials used in this wheel are indicated below and the approximate weights of a similar wheel for the 1 ton vehicle which corresponds with the other wheels tested is also indicated.

	As Built for 7.50 x 20 Tire	Estimated for 6.00 x 16
Wood -	13 lbs.	6 lbs.
Steel -	240 lbs.	80 lbs.
Total Tire -	253 lbs.	86 lbs.
Wheel -	43 lbs.	
Total Tire and Wheel -	296 lbs.	

These wheels are now being re-designed, and some form of resilient tread material will be used on the next wheels submitted for test. These re-designed wheels will probably be ready for further test within the next three or four weeks.

Fig. 9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46315-D.

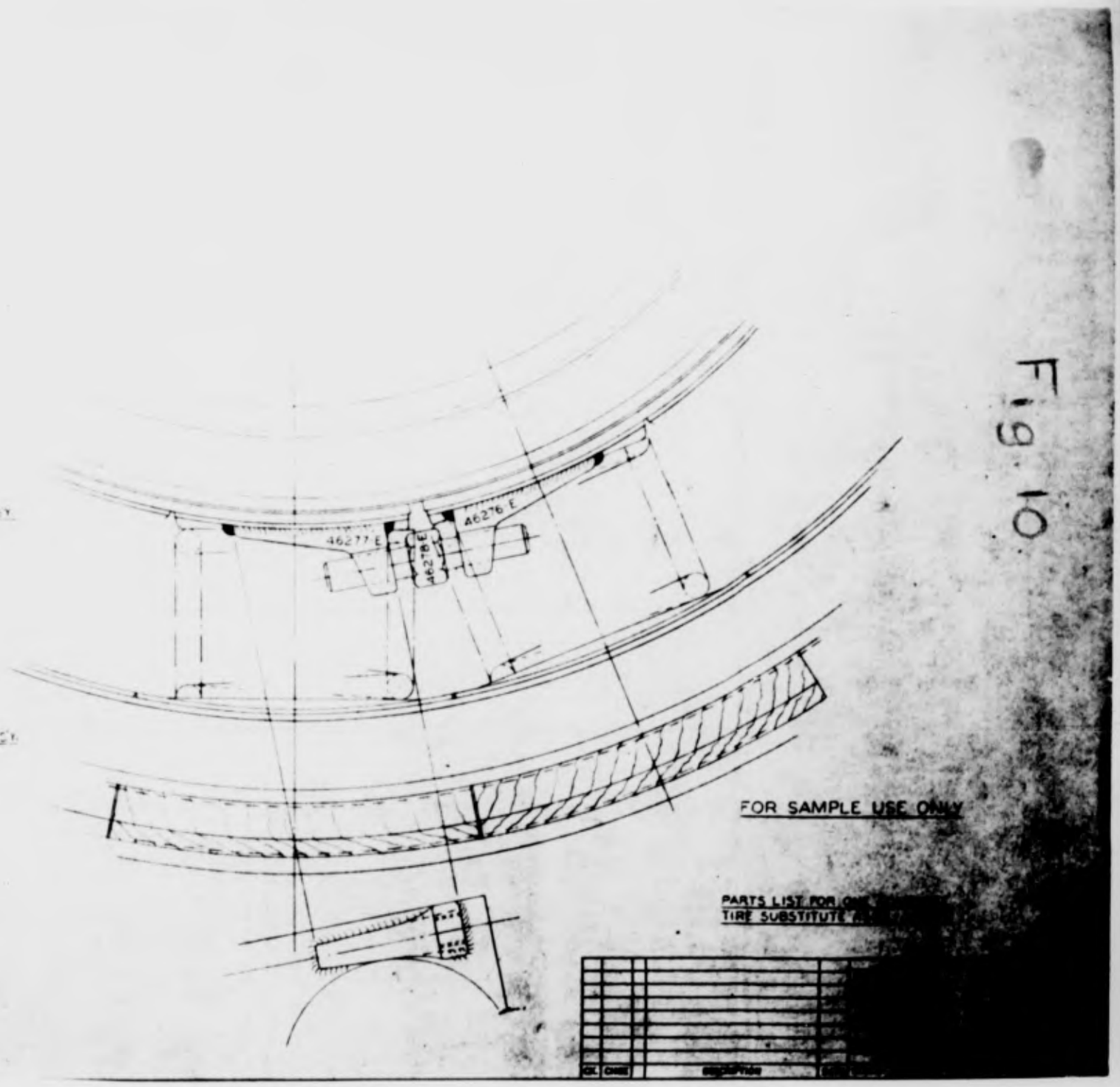

46277 E
46278 E
46276 E
FOR SAMPLE USE ONLY
PARTS LIST FOR ONE
TIRE SUBSTITUTE

Fig 10

AMBAT MAJOS-STEEL SPOKE WHEEL

SUBSTITUTE FOR THE PNEUMATIC TIRE

This wheel, which was designed by Mr. Burtne Majos and built by the Ambat Corporation with their own funds, obtains its resiliency through the steel spokes.

The wheel was submitted by the inventor for test at Camp Holabird on August 24th. While more complete tests would have been desirable at first time, the tests which were made, and the subsequent inspection of stress on all the design made it appear that the wheel had possibilities. As a result, the Army requested two additional wheels for further tests.

In the photographs, Figure 11, and the drawing, Figure 12, indicate the design and construction of this wheel.

The original wheels which the inventor made contained a wooden felloe. As a result of our investigations it was suggested that this be used on the wheels which were submitted to Holabird, and this was done. The test trials and the weights are as indicated below:

Incremated Fabric	30 lbs.
Steel and other Metal Parts	108 lbs.*
Total Tire and Wheel	138 lbs.

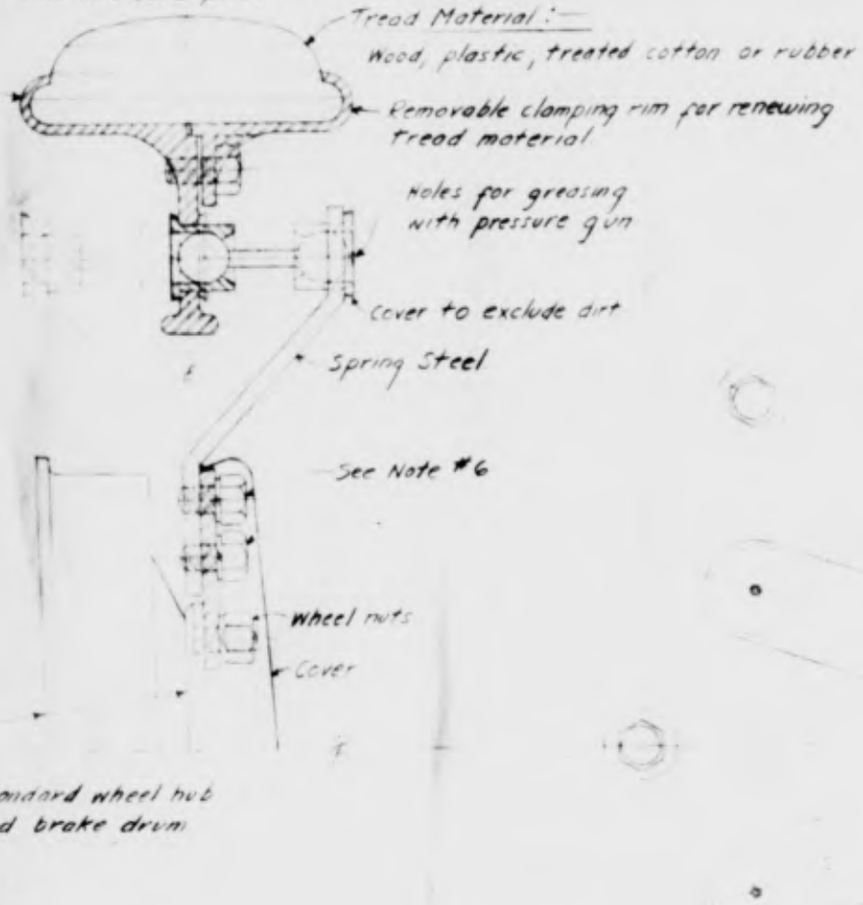
* This wheel was made entirely from castings and in order to obtain the wheel quickly manganese bronze was used for the rim. The wheel also being a first model was considerably over-designed.

The next wheels which are now being built for the test will probably weigh between 80 pounds and 100 pounds, of which 40 pounds will be tread material. If put in production the rim and other parts would be either forged or made from dies and it is estimated the total weight exclusive of tread material would be about 60 pounds.

This type of construction would of course require no spares. This comparisons of weights of materials should be between four wheels of this type and five of the standard pneumatic.

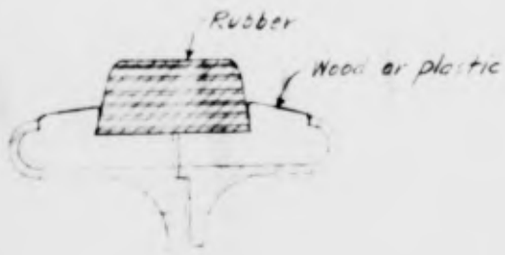
A contract is now being prepared for the construction of the ten wheels for further test. It is likely that six to eight weeks will be required for their construction and assembly.

NOTE: When weight is on wheel rim hits curb first



Standard wheel hub and brake drum

Fig. 12



ALTERNATE TREAD CONSTRUCTION
EMPLOYING NARROW STRIP OF RUBBER

GENERAL NOTES:-

1- Number of parts have been reduced to one fifth of that employed in first model.
2- Jumping of tread experienced in rubber tires does not occur in this wheel.
3- Suitable for military use because it is bullet-proof.
4- No limitation of speed.
5- Production model, made of pressed steel, will be considerably lighter.
6- Substitute rivets for bolts in production model.
7- Flexibility may be adjusted to suit any load.

AMPAT CORPORATION
1450 BROADWAY, NEW YORK, N.Y.

Drawn by E Hajos Date: May 7, 1942
Checked by
Approved

No 2

MARTIN - RUBBER SPOKE WHEEL

SUBSTITUTE FOR THE PNEUMATIC TIRE

This wheel, invented by J. V. Martin, has been in the process of development for the past eight or ten years. The present design has been built and run satisfactorily some 11,000 miles on a standard passenger car.

The general construction and appearance of this wheel is shown in Figures 13 and 14, and the drawing Figure 15 shows the cross section and inner construction.

The standard automotive wheel is used for the center. Most of the outer rim is removed, which results in an appreciable saving in steel.

The spokes are of rubber. While substitutes are being tried, it is likely that a good grade of rubber not subject to permanent set will be required. The maximum stretch under impact is much below the elastic limit of the rubber used.

The outer rim consists of three separate hoops which permit deformation to road contour. Each hoop contains a solid hickory ring, rubber covered and with sufficient tread for the mileage or service required. Laminated instead of solid hickory is being experimented with and seems to have definite advantages.

This wheel has more available resiliency and cushioning than the pneumatic tire. Table II illustrates this. It shows the relative deflections under various loads of the Martin Wheel and the standard military pneumatic tire inflated to 36 pounds pressure.

Table II

Load in pounds	Deflection Martin Wheel	Deflection pneumatic tire
600	.395"	.481
800	.556	.592
1000	.698	.697
1200	.882	.807
1400	1.117	.922
1600	1.352	1.039
1800	1.616	1.160

This additional resiliency is of particular advantage at high speeds and over rough ground. It provides easier handling of the car and should result in less damage to the car and driver.

The tread area in contact with the road is less than with the pneumatic tire. Figures 16 and 17 illustrate this. This might indicate less traction in mud and sand, but actual tests prove this is not the case. This smaller tread area might also indicate that more tread wear would take place. However, the lower temperature of operation of the Martin Wheel will tend to reduce tread wear.

Tests will be made to determine the tread wear on the Martin Wheel as compared to the pneumatic tire. The use of laminated hickory hoops instead of solid hickory tends to increase the tread area and is one of the advantages of the laminated hickory.

Since the Martin Wheel does not contain air and will apparently stand as much or more impact than the pneumatic without destructive damage, only four wheels, in place of the five pneumatics, would be required on the four wheeled vehicle. Thus an appreciable saving in both rubber and steel would result from the use of the Martin Wheel.

Table III following indicates the comparative weights of five pneumatic tires and wheels and four Martin wheels.

Table III

Materials	Five pneumatic tires (mud and snow tread), standard tube and wheel	Four Martin Wheels as tested	Saving
Rubber Compound	127.5 lbs.	108 lbs.*	19.5 lbs.
Steel	123.5 lbs.	46 lbs.	77.5 lbs.
Cotton Fabric	25.0 lbs.	-	25.0 lbs.
Wood	-	54 lbs.	(54 lbs.)
Total	276.0 lbs.	208 lbs.	-

*Redesign will reduce this materially.

These wheels had been designed before there was any rubber shortage. It is the inventor's opinion that a redesign could eliminate approximately 25% of the rubber required in wheels for combat service. For administrative use some of the spokes could be left out with a corresponding reduction of approximately 40% in rubber required.

Four of these wheels were built by the inventor and submitted at Camp Holabird on August 25 for test. More complete road tests were made on these than on the other wheels, since the car could be completely equipped.

Further tests were made with these four wheels on the 1/4 ton vehicle at the Ford tank test course at Detroit. The car was run at varying speeds from 20 to approximately 50 miles per hour over a series of ditches one to two feet deep. It was circled at its minimum driving radius at speeds up to 25 miles per hour. It was also driven up an incline and off a sheer drop of about three to four feet at speeds up to 30 miles per hour. Duplicate tests were made with the car equipped with the pneumatics and a motion picture film was taken of all these tests.

Subsequent to the tests at Camp Holabird the Ordnance department requested ten of these wheels for more comprehensive tests. A contract has been made with Factory Products Company at Detroit for the construction of these wheels. A large part of the work will be done at the Ford Motor Company.

Following the Detroit tests and a further inspection of these wheels by Lt. Col. J. H. Colby and other officers, the request was increased to twenty, the majority to be equipped with the mud and snow tread and four or five with the sand tread. These will be ready for test within four to eight weeks.

The photograph, Figure 18, indicates a possible modification of this type of wheel, which again would substantially reduce the amount of rubber required. This particular wheel with the coiled spring spokes is merely a hand made model built to illustrate the principle. It is likely that considerable development work would be necessary before this type of wheel would be ready for further test.

The Ordnance Department have specifically requested that we endeavor to develop this spring spoke wheel because of the real saving in rubber which would result if this type of construction approaches in performance that of the rubber spoke wheel. Estimates are now being prepared and a contract will in all probability be entered into covering the necessary research and development for this type of construction.

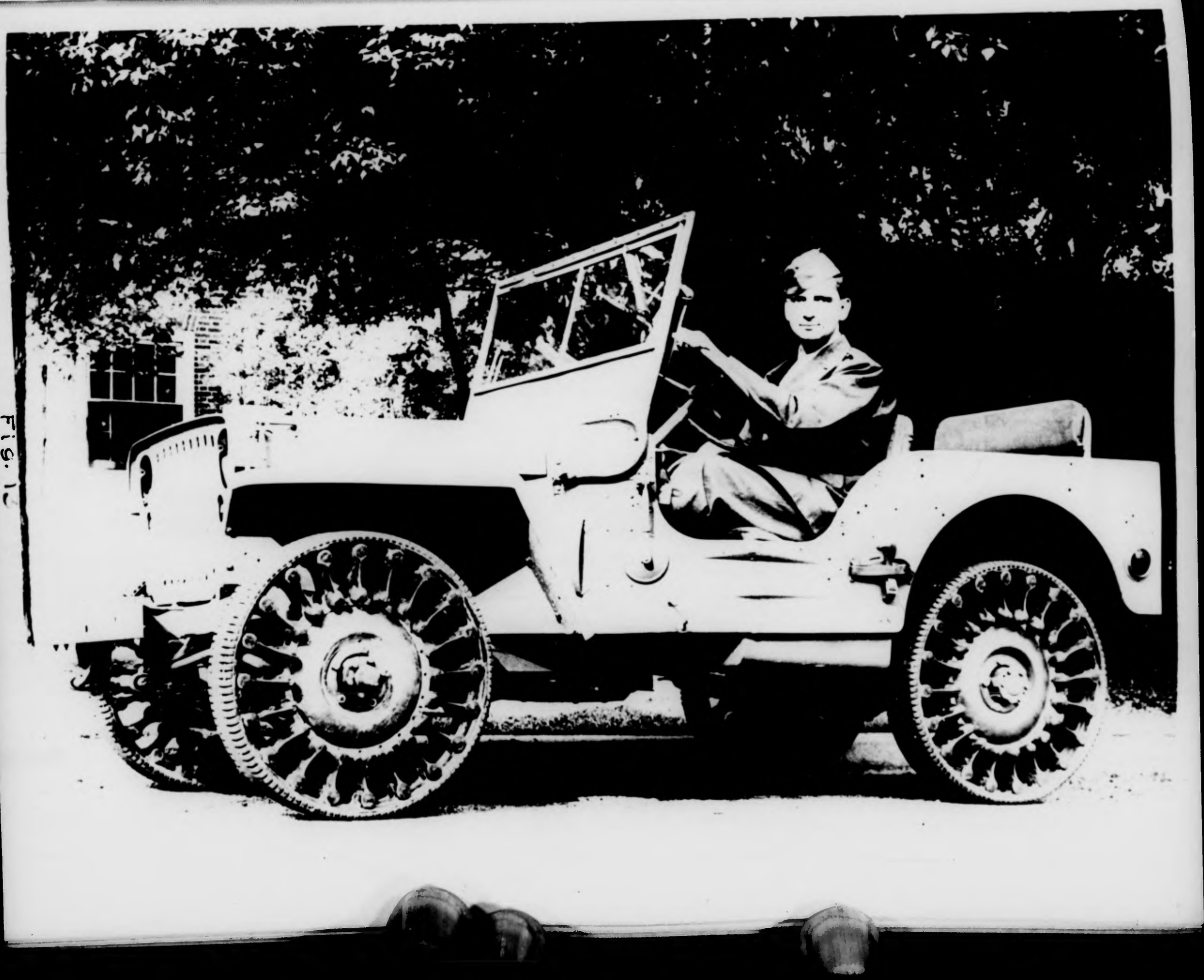


Fig. 1

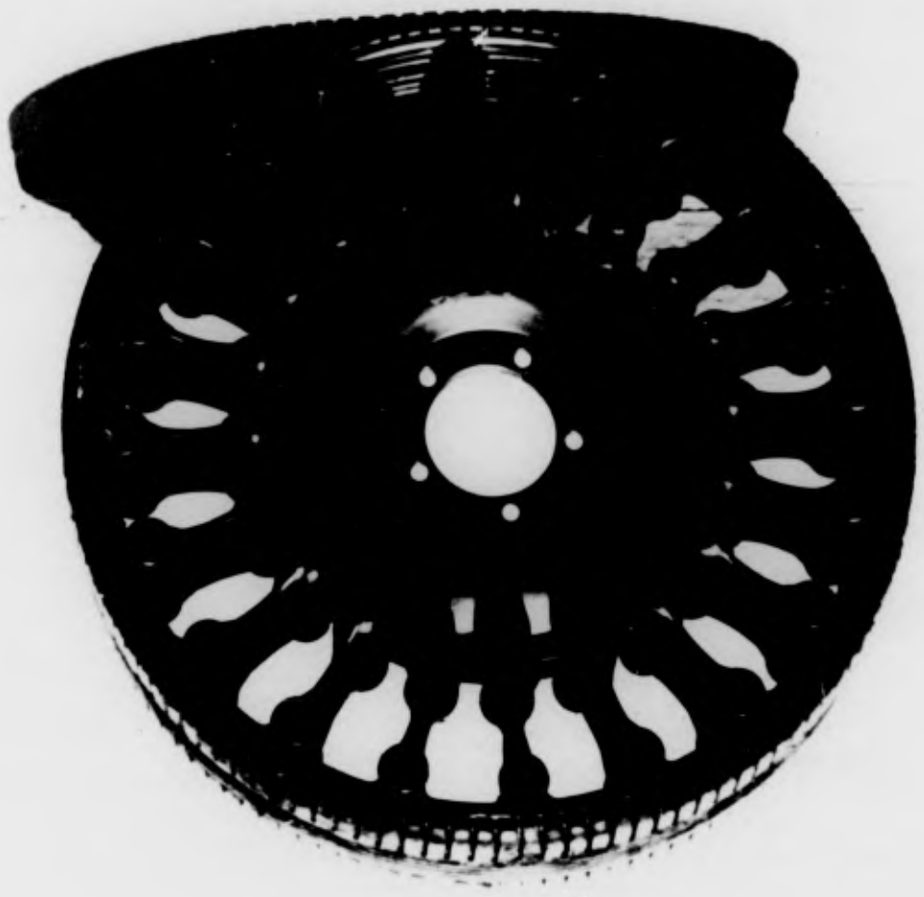


Fig. 12

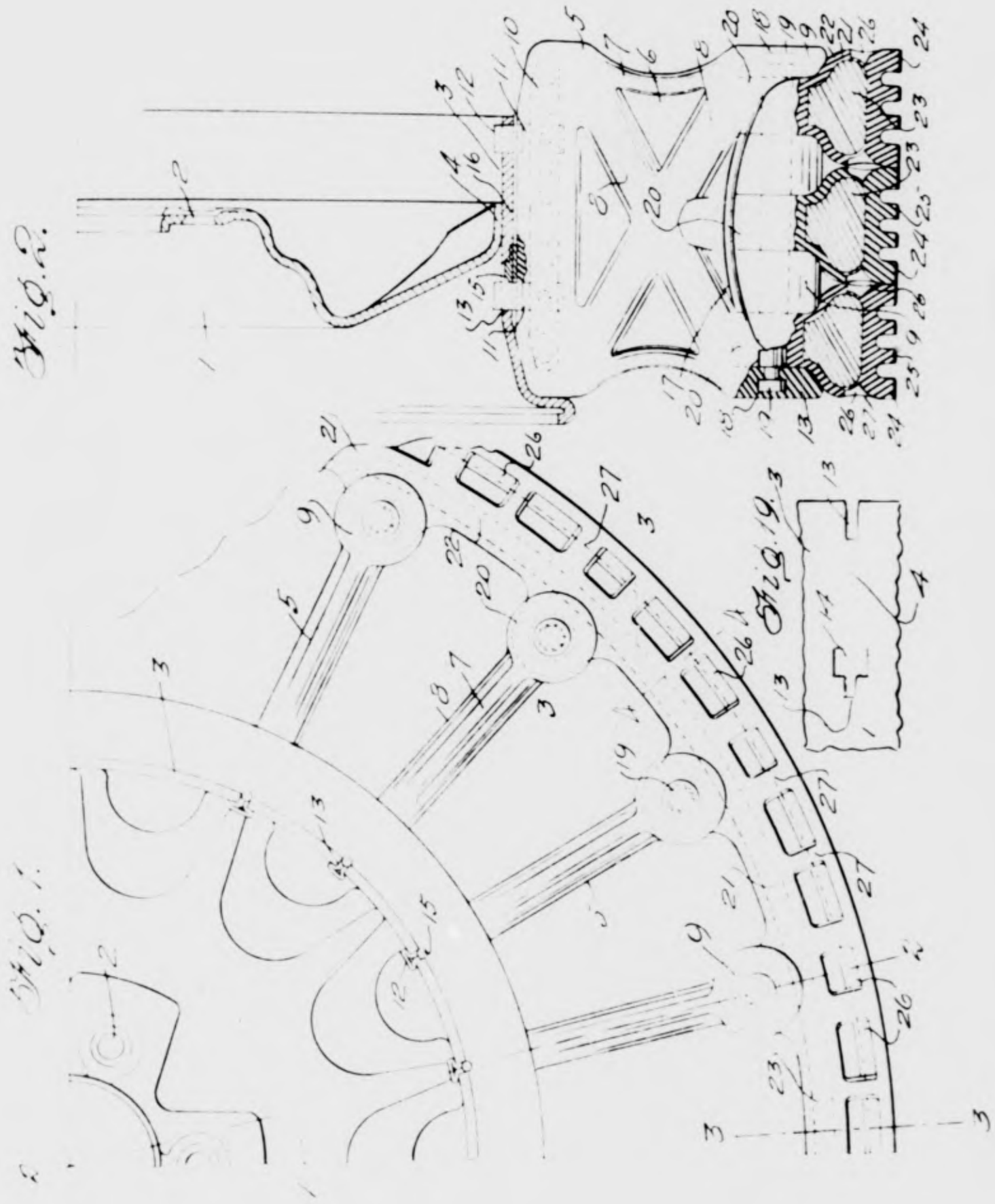


Fig. 15

Fig. 16

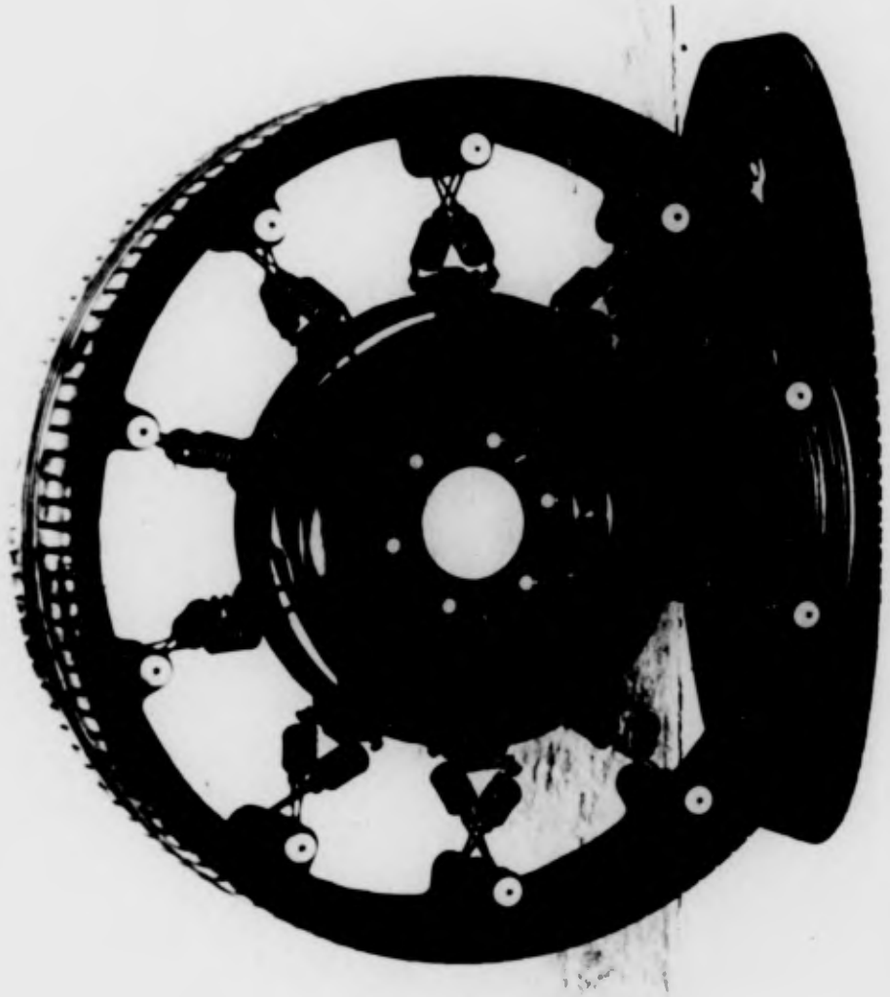


Fig. 12

SECTION III

TIRES AND WHEELS UNDER CONSTRUCTION

This Section of the report contains brief information and drawings or sketches where available showing the tires or wheels which are now being built for test. Some of these are being made under contract with our office and others are being made without expense to the Government. They have all been designed as a possible substitute for the pneumatic tire.

It is anticipated that all of these wheels will be completed and submitted for preliminary test within the next six to eight weeks.

TARN-COILED SPRING TIRE

Four of these wheels, which consist fundamentally of a round wire, coiled spring annulus with an outer tread material, are being made up under contract. These are being made as a tire to fit on the standard military rim.

Assembly drawings of this wheel have not been completed and are consequently not included.

The construction work is well along on these wheels but the contractor estimates that they will not be ready for test until the latter part of November.

NEWTON-STEEL TIRE

Two of these wheels are now under construction under a contract. The detailed assembly drawing of this tire has not been completed and consequently is not included. It is being made to mount on the standard military rim.

This construction consists essentially of thin sheets of steel formed in the shape of the pneumatic tire with an inner continuous supporting rim. Between this inner supporting rim and the metal tire a cushioning member of cork, brake-lining material or something similar is to be used to assist in transferring the static load and impact to all parts of the tire. The metallic tire will be equipped with some form of tread material or cover such as the United States Rubber Company tire sandal or possibly one of the other impregnated carpet-like materials.

These wheels should be completed and ready for test within four to six weeks.

KELSEY HAYES WHEEL COMPANY - METAL TIRE

Figure 19 illustrates the construction of this tire. These experimental tires are being machined from a casting and heat treated. On a production basis they would probably be forged or pressed from sheet steel. A tread of one of the impregnated carpets or possibly the Weiswasser material will be used.

Originally, it had been planned to construct two of these tires, but flaws in the original casting will probably result in only one being submitted for the first preliminary tests. This tire is being made without expense to the Government and will probably be ready for test within four to six weeks.

SAME AS SHOWN ON EX-16624.

NOTE:-
FOR ALL OTHER INFORMATION
SEE EX-16624

Fig. 19

N.T.S.

KELSEY-HAYES WHEEL

KNOX - "V" SPRING TIRE

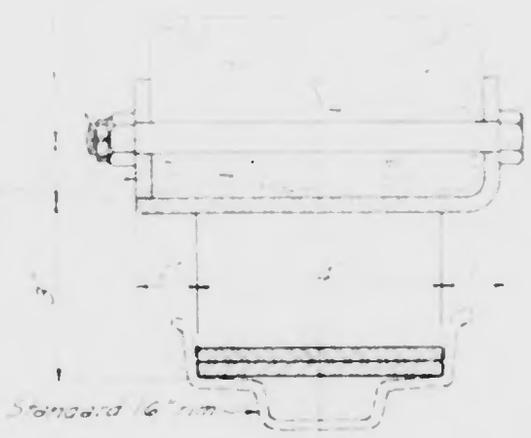
Figure 20 illustrates the design of this wheel which has been built by Mr. Knox without expense to the Government. Two of these wheels have already been shipped to Camp Holabird for test, but the tests will not be conducted until at least three or four other wheels are ready.

It appeared to us that rather early fatigue and crystallization would take place at the bottom of the "V" with this type of construction. However, Mr. Knox believed that considerable mileage could be obtained before this fatigue would take place, and that due to the simplicity of construction of this type of wheel we should consider it among the others which we were testing.

3

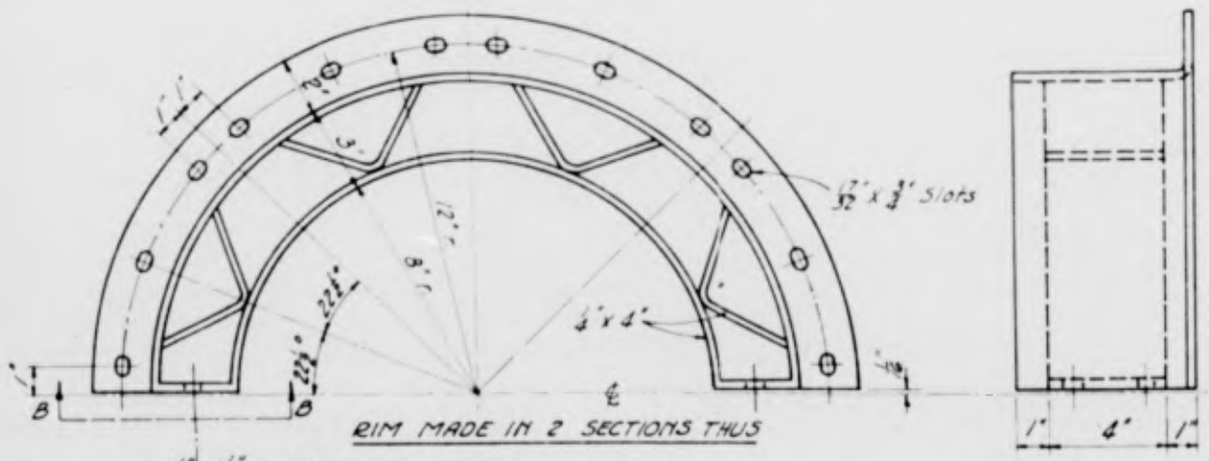
TIRE SHOWN ASSEMBLED

OUTSIDE

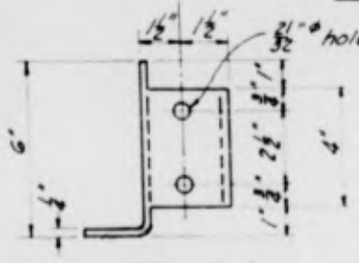


SECTION A-A

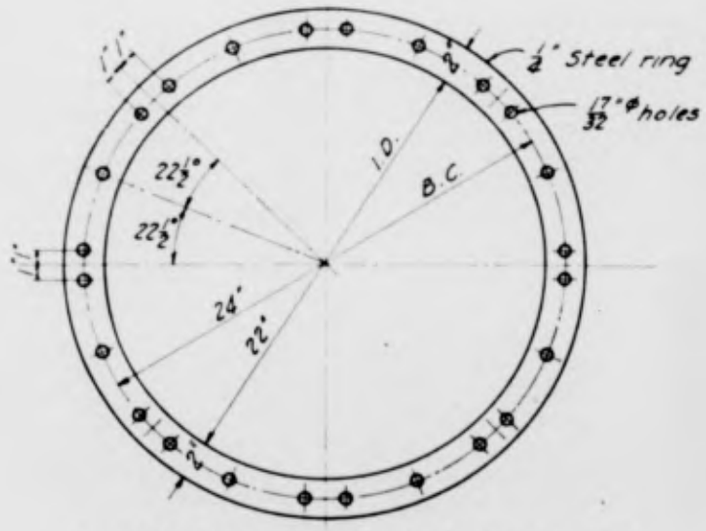
DETAIL OF FIBRE BLOCKS



RIM MADE IN 2 SECTIONS THUS



VIEW B-B



PRESSURE PLATE MADE IN 1 SECTION THUS

KNOX DEMOUNTABLE TIRE

PATENT APPLIED FOR

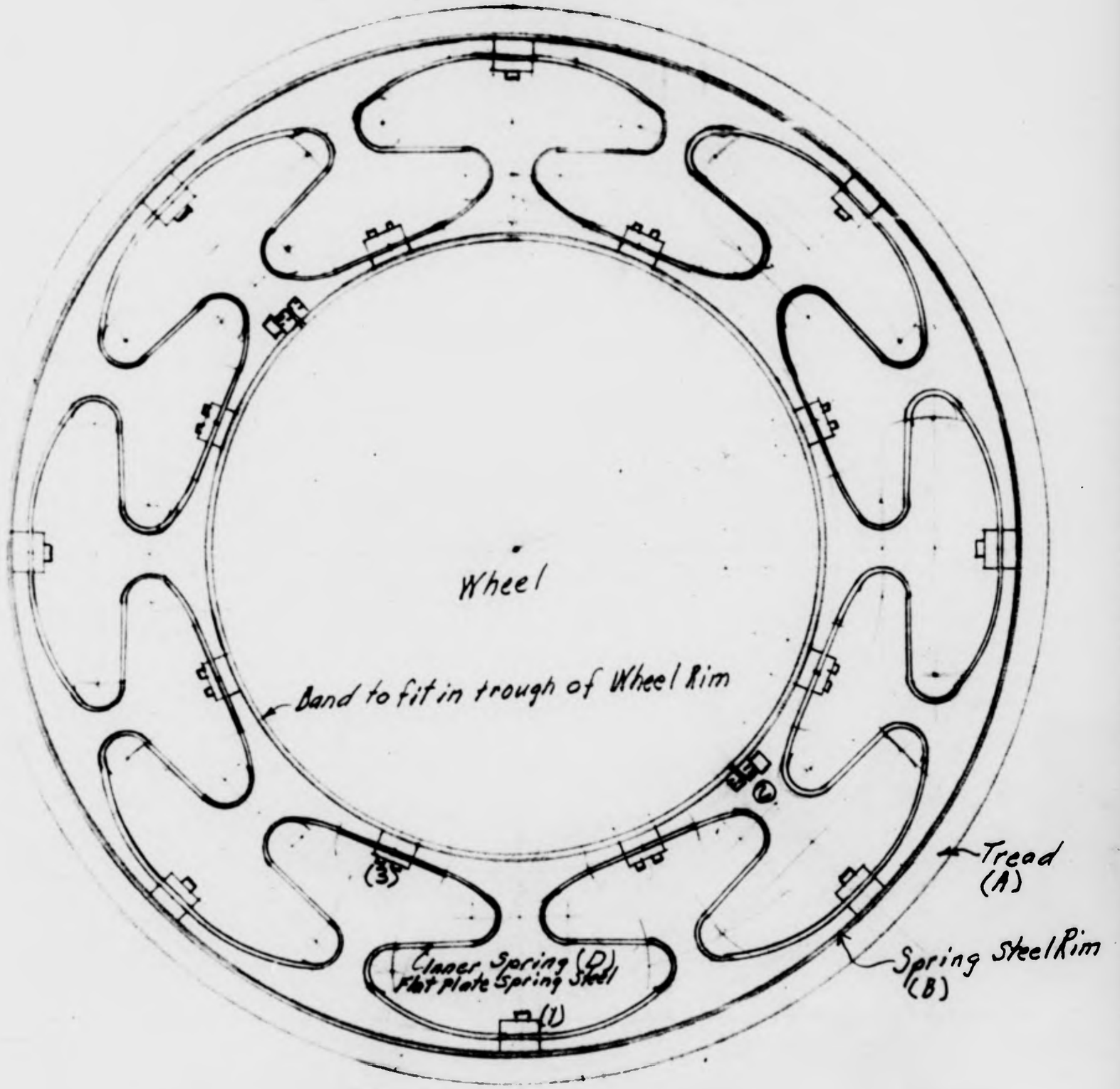
DRAWN BY MASON JACKSON

JOOR - "S" SPRING TIRE

Figure 21 illustrates the construction of this tire which is being built under contract. This tire is somewhat similar in construction to the one which has been submitted by Mr. Knox and we believe has the same criticism, that early fatigue is likely to take place at the point of attachment of the springs to the inner and outer rim.

Construction has just been started on these tires and it is not likely they will be ready for test until the latter part of November.

5714 Newport St
Houston, Texas
Oct. 16, 1942.



Typical
DESIGN FOR STEEL TIRE TO REPLACE PNEUMATIC TIRES.
(¼ Size)

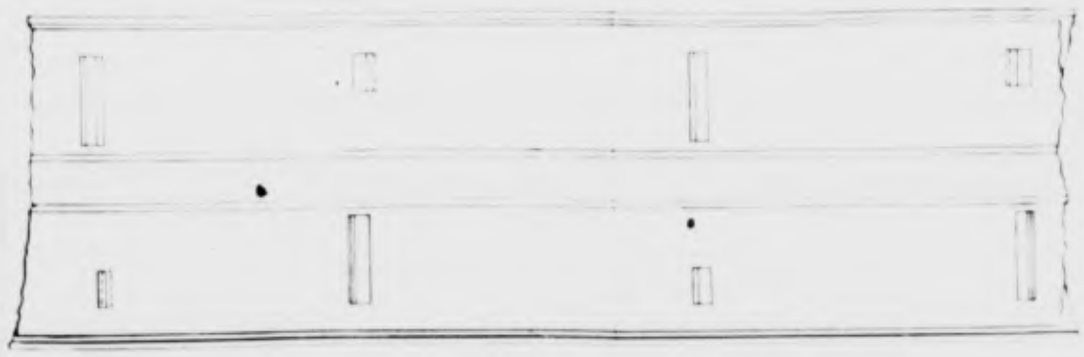
Fig. 21

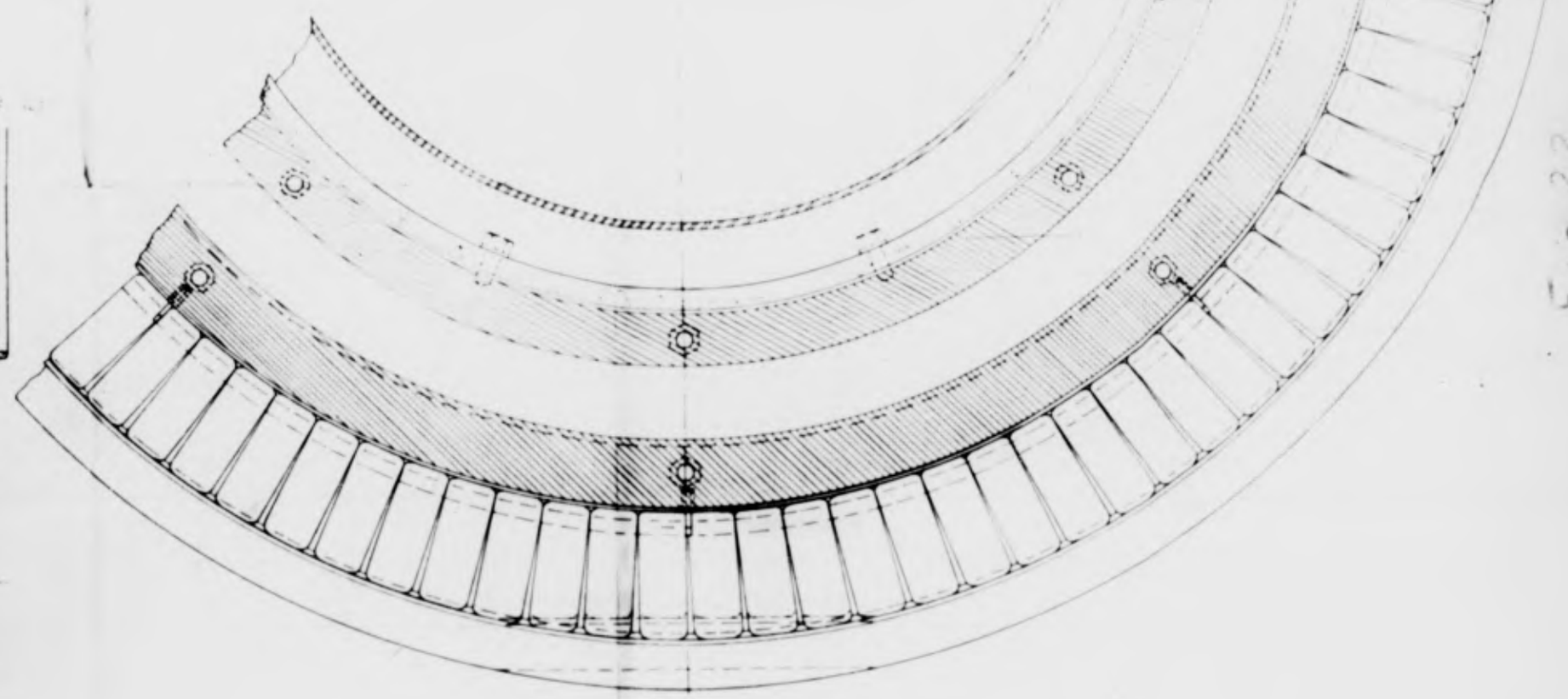
BROWN DOUBLE COILED SPRING TIRE

Figure 22 illustrates the general construction of this tire which is being built under contract, for mounting on the standard military rim.

Its general design is somewhat similar to the one being designed and built by Tarn, except this wheel uses two sets of coiled springs instead of one, and is using flat spring steel instead of round wire as in the Tarn construction.

One of the various tread materials which are being experimented with will be used on these four wheels on which construction has just been started. It is not likely that these wheels will be ready for test until the latter part of November or early in December.





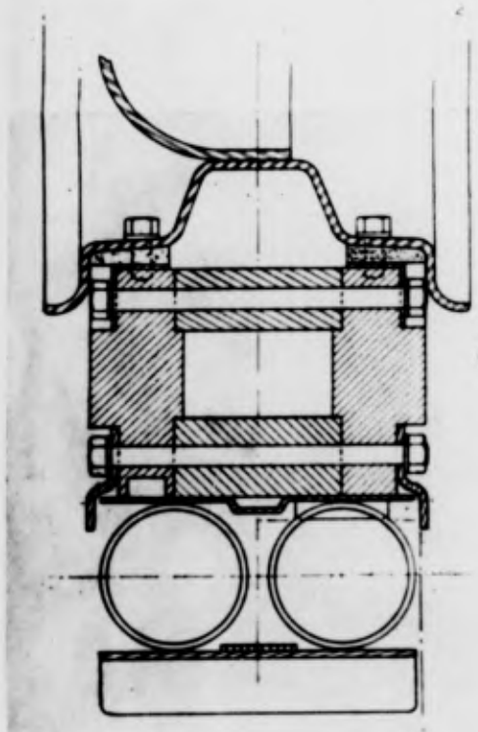


FIG. 22.

MAC LEAN-RUBBER BISCUITS TIRE

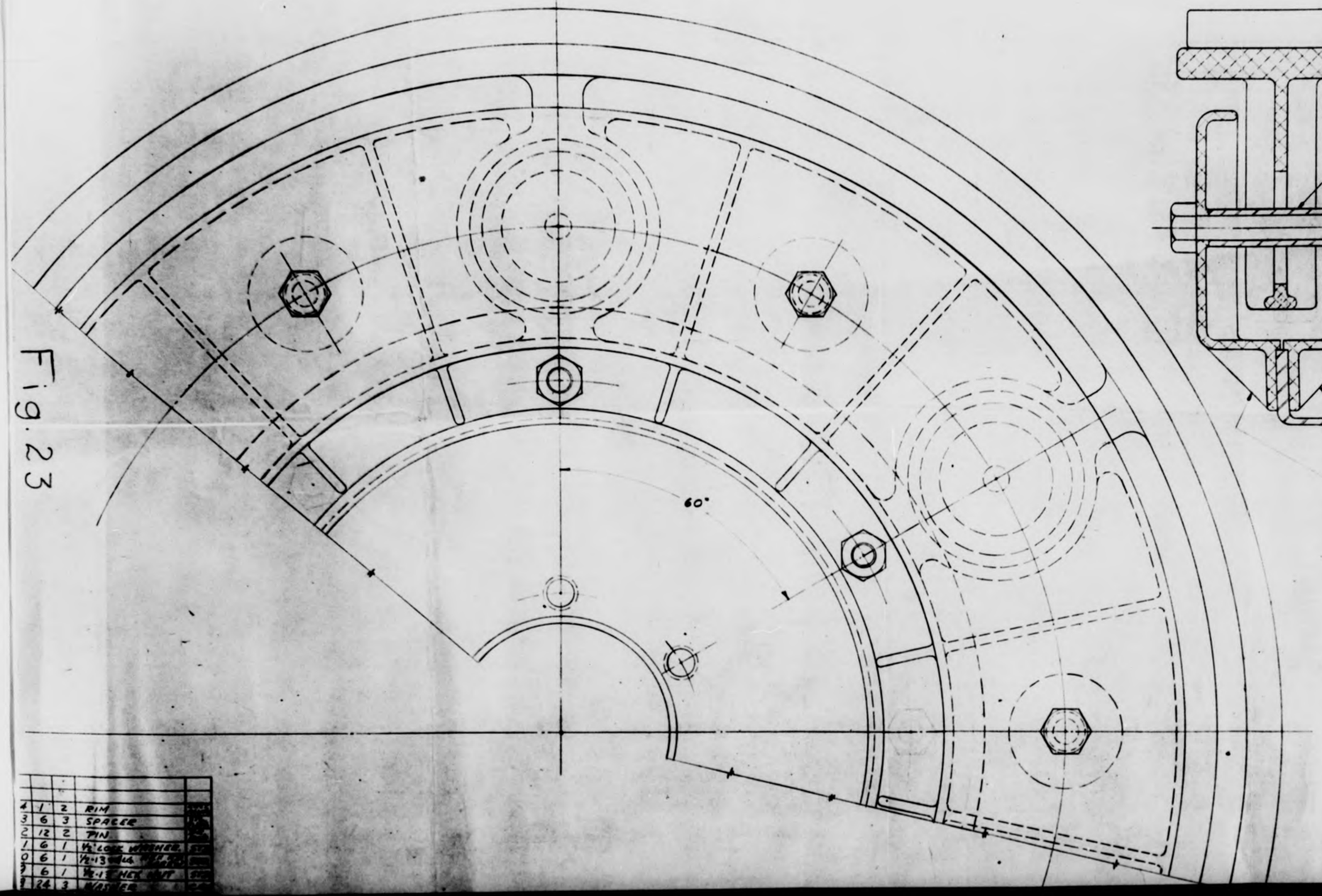
Figure 23 illustrates the general construction and principles of this design, which is being built for the standard military rim.

The inventor informs me that wheels of this type were built and used on some trucks in the Northwest in 1928 and '29 and were at least far superior in performance to the solid rubber tires which were in use at that time.

While this construction uses some rubber, it is only a small proportion of that used in the standard pneumatic.

Four of these wheels are being built under contract. The construction has just recently been started and delivery will probably be made early in December.

Fig. 23



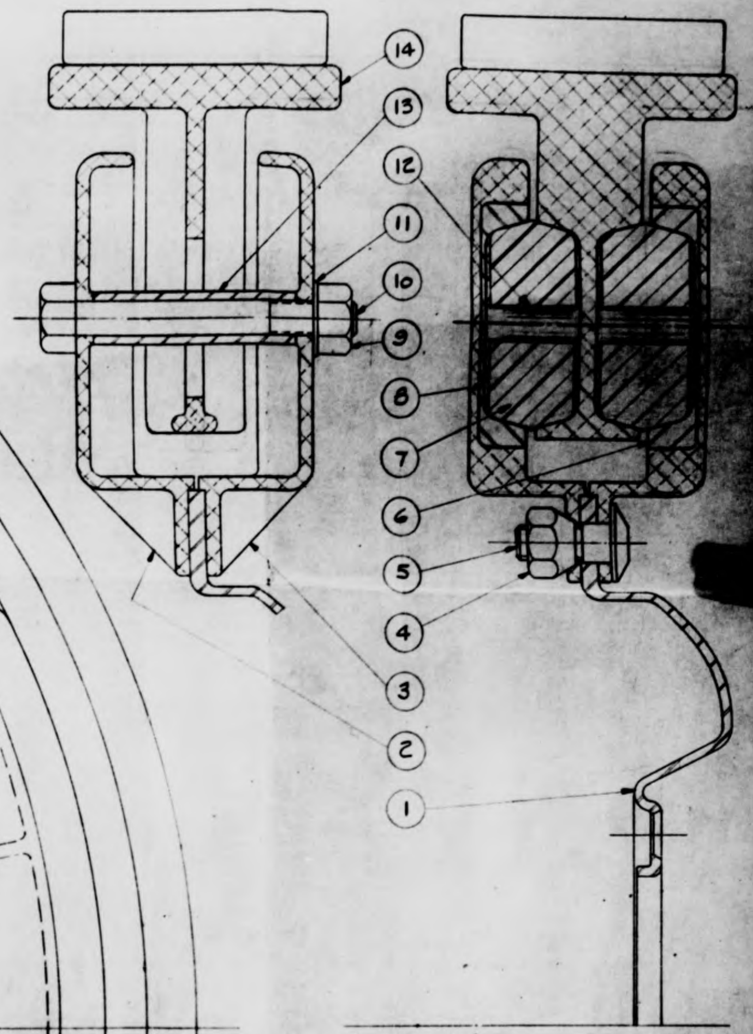


Fig. 23

4	1	2	RIM
3	6	3	SPACER
2	12	2	PIN
1	6	1	½" LOCK WASHER
0	6	1	½-13 HEX NUT
9	6	1	½-13 HEX NUT
8	24	3	½-13 HEX

TITLE:
WHEEL FOR ¼ TON VEHICL

DIVISION 12

TRANSPORTATION DEVELOPMENT